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Study of Compressive Strength of Various Grades of Concrete using Different Sizes of Cubes

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Abstract: **Concrete being the most versatile material of construction holds the property of stronger in compression. This property enables the concrete for most of its utility in construction. Since the strength of concrete is related to the structure hardened cement paste, it assumes more importance. The size of test specimens for compressive strength is prescribed in relevant codes, however it varies from country to country and often more than one size is permitted.The restraining effect of the platens of the testing machine extends over the entire height of a cube but leaves unaffected a part of a test cylinder. It is, therefore, to be expected that the strengths of cubes and cylinders made from the same concrete differ from one another. It is difficult to say which type of specimen, cylinder or cube, is 'better' but, even in countries where cubes are the standard Specimen, there seems to be a tendency, at least for research purposes, to use cylinders rather than cubes.In the present investigation the effect of different cube size on compressive strength of concrete have been studied. The variations have been made in the size of specimen, grade of concrete & age of concrete. Four different sizes of specimen viz: 150 mm, 125 mm, 100 mm & 75 mm were used. A total of 4 mixes were prepared by varying the grade of concrete mixes. Based on the laboratory results the compressive strength was reported to increase with the decrease in specimen size. Moreover the relative strength of concrete were obtained and it was found that it also increases with the decrease in specimen size and remains unaffected due to age and grade of concrete.**

KEYWORDS: Compressive Strength, Sizes of Cube, Grade of concrete.

I. INTRODUCTION

Concrete is a construction material comprising of several constituents viz. cement, fine aggregate, coarse aggregate and water. The quality of concrete depends on its mix composition, consistency of its constituents as well as its workmanship on site. The quality of concrete needs stringent monitoring to ensure that it meets the required standard. Over the years, engineers have developed many tests to assess concrete quality. The tests commonly used are the compression test, tensile test and workability test. The most useful property of concrete is compressive strength. Factors affecting the strength of concrete can be broadly grouped into those depending upon the testing methods and the others independent of the testing methods. Factors depending on testing methods are the size of test specimen, size of specimen relative to maximum size of aggregate, moisture condition of specimen, rate of loading adopted and of machine used. Those independent of testing methods are type & age of cement, type & size of aggregates, degree of compaction, curing methods and type of stress situation that may exist (uniaxial, biaxial and triaxial)**[5]**.

The size of test specimens for strength testing is prescribed in the relevant standards, but occasionally more than one size is permitted. The form of specimen most commonly adopted for compression test is cube of 150 mm size. Moreover, from time to time arguments in favour of use of smaller specimens are advanced. This point out their advantages that smaller specimens are easier to handle and are less likely to be accidentally damaged; the moulds are cheaper; a lower capacity testing machine is needed; and less concrete is used, which in the laboratory means less storage and curing space, and also a smaller quantity of aggregate to be processed. On the other hand, the size of the test specimen may affect the resulting strength and also the variability of test results. For these reasons, it is important to consider in detail the influence of the size of specimen on strength test results. Concrete composed of elements of variable strength is reasonable to assume that the larger the volume of the concrete subjected to stress the more likely it is to contain an element of a given extreme (low) strength. As a result, the measured strength of a specimen decreases with an increase in its size, and so does the variability in strength of geometrically similar specimens. Because the influence of size on strength depends on the standard deviation of strength. It follows that the size effects are smaller the greater the homogeneity of the concrete. In the case of tests on the strength of concrete, we are interested in the averages of extremes as a function of the size of the specimen. Average values of samples chosen at random tend to have a normal distribution, so that the assumption of this type of distribution, when average values of samples are used,

does not introduce serious error, and has the advantage of simplifying the computations. In some practical cases, a skewness of distribution has been observed; this may not be due to any 'natural' properties of concrete but to the rejection of poor quality concrete on the site so that such concrete never reaches the testing stage. In the present study an attempt has been made to investigate the effect of size of cube specimen on the compressive strength of concrete by varying different sizes of cube mould and grade of concrete.

II. EXPERIMENTAL PROGRAMME

The experimental Programme involves various processes of material testing, mix proportioning, mixing, casting and curing of test specimens which is elaborated in the following sections.

A. Materials Used

The materials used in the preparation of concrete mix includes cement, fine aggregates and coarse aggregates. Each material was tested &its physical properties are described below.

Cement

Ordinary Portland cement confirming to 53 Grade (as per IS 12269: 1993) were used as the binder material. The cement was having a normal consistency of29%, with initial setting time and final setting times of 30 minutes and 610 minutes respectively.

Fine Aggregate

Locally available river sand of 4.75mm down graded to 150 micron is used as fine aggregate. The fineness modulus and specific gravity of fine aggregate are 3.83 & 2.6 respectively. The properties were determined as per IS 2386: 1999. Sand was confirming to Zone-2 as per the graded sample versified as per IS 383: 1970.

Coarse Aggregate

Two single sized crushed granite stone aggregates ranging from 12.5 mm to 2.36 mm and 20 mm to 4.75 mm (10mm and 20mm sizes) were used in respective proportions in concrete mixes. Thefineness modulus of coarse aggregate are 6.92 and 7.87 respectively. The properties were determined as per IS 2386-1999.

Water

The water used were the potable water as per the recommendation of IS: 456 (2000) for mixing and curing of concrete.

Fig 1: Materials used

B. Mix Design

The mix was designed as per IS 10262: 2009. The mix proportioning is carried out to achieve specified characteristics at specified age, workability of fresh concrete and durability requirements. Four concrete grade M 20, M 25, M 30 & M 35 were proportioned according to the procedure as mentioned in the code. Details of these mixes are presented in Tables 1.

C. Mixing of Concrete, Casting and Curing of test Specimens

The entire process of mixing of all the constituents was achieved by machine mixing. Cement, fine aggregate and coarse aggregate was first mixed dry for two minutes in the mixer and then the water were added and mixing continued for another 3 minutes. The total mixing time was kept at 5 minutes until a homogeneous mixture was obtained. Compaction was done initially by tamping rod and then by means of vibration table. All specimens were de molded after 24 hours and stored in water until the age of testing. A total of 48 specimens were casted taking into account four different sizes of cube moulds.

D. Test methods

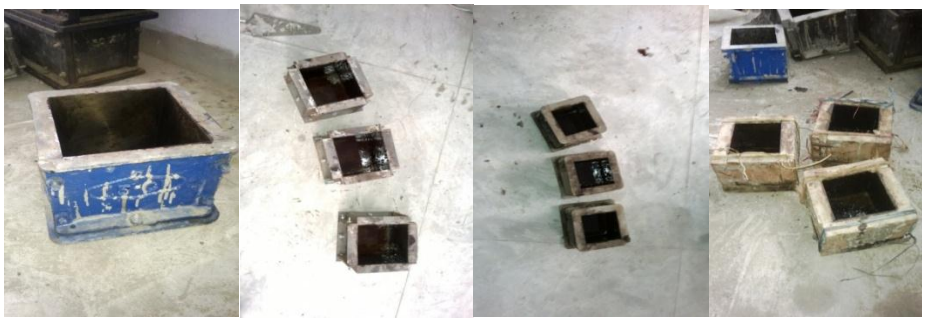
The fresh concretes were tested for slump. However the hardened concretes were tested for compressive strength discussed below.

Workability Test

Workability tests were performed using Slump moulds as it is the quick measure of workability of concrete mixes. The slump test was done in accordance with the IS 1199-1959.

Table 1: Mix details of Concrete Mixes

MIX NO.	Grade of concrete	W/C	Cement (Kg/m^3)	Fine Aggregate (Kg/m^3)	Water content(kg/m^3)	Coarse Aggregate (Kg/m^3)
M-1	M 20	0.57	346	674	197.16	1150
M-2	M 25	0.50	394.32	634.608	197.16	1150
M-3	M 30	0.45	438.13	604.24	197.16	1143.74
M-4	M 35	0.40	492.90	571.064	197.16	1129.854



(a) Different sizes of cube moulds used in the project (viz: 150mm, 125mm, 100mm, 75mm)

(b) Machine Mixing(c) Compaction of Specimens(d)Casted specimens

(d) Curing of specimens

Fig 2: Different operations during Preparation of Specimens

Fig.3: Slump Test

Compressive Strength Test

The compressive strength test was performed according to IS 516: 1959. Four different cubes specimen of size 150 mm, 125 mm, 100 mm & 75 mm were prepared for each mix. At the end of 24 hours the specimens were removed from the moulds and were placed in clean water for curing. After 7 and 28 days of curing, the specimens were taken out from the curing tank for testing.

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Fig 4: Compressive Strength Test

III. RESULTS AND DISCUSSION

The results of the experimental program conducted to understand the size and shape effect on the compressive strength of concrete is analyzed in detail. Tables 2 present the results of axial compression tests conducted on plain concrete specimens.

A. Effect of size of specimen on compressive strength of concrete

Figs.5 & 6 depict the variation of compressive strength with cube size of 150 mm, 125 mm, 100 mm and 75mm based cubes. Fig-5 shows the variations in strength at the age of 7 days and it may be noted from this figure that for all grade of concrete the strength increases as the specimen sizes decreases irrespective of grade. But a decrease in strength was noted for 125 mm cube size. Further, it was also noted that change in strength was not more evident for smaller size specimens, everything being constant. A similar type of variations in strength was obtained at the age of 28 days as shown in fig.6.

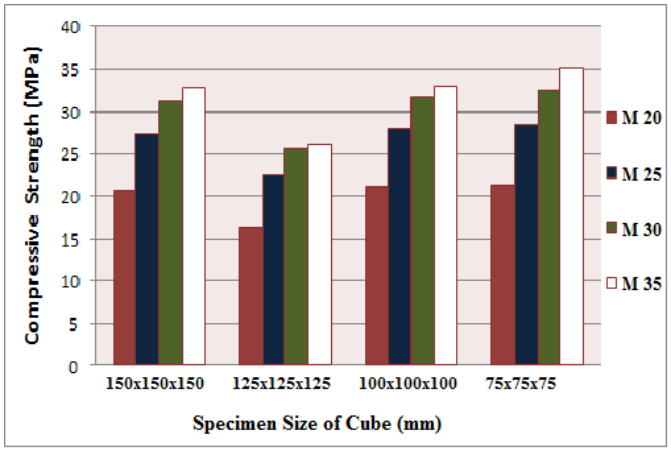

Fig.5: Effect of specimen size on 7-days compressive strength

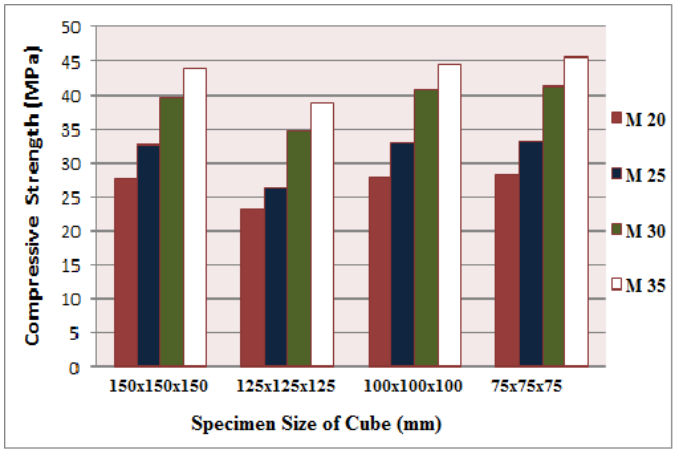

Fig.6: Effect of specimen size on 28-days compressive strength

B. Effect of size of specimen on Relative compressive strength of concrete

Fig.7 & 8 depict the variation in relative compressive strength to 150 mm cubes at the age of 7 & 28 days for various grades of concrete. The result shows that the relative strength values increases as the size of specimen decreases. However the relative strength values decreases in case of 125 mm size cube. Grade of concrete has a little effect on the relative strength, as seen from the result the relative strength increases as the grade of concrete increases. However the relative strength is not so much affected by specimen size irrespective of grade of concrete. Increase in age increases the relative strength irrespective of grade of concrete. In general increase in grade & age of concrete contribute little increase in relative strength, with decrease in size of specimens.

Table 2: Compressive strength of concrete for Various Grades

MIX NO.	Grade of concrete	Size of Specimen (mm)	Avg. 7-days Compressive strength (Mpa)	Avg.28 days Compressive strength (Mpa)	7-days Relative Strength to 150 mm Cubes	28-days Relative Strength to 150 mm Cubes
M-1	M 20	150x150x150	20.70	27.60	1.0	1.0
		125x125x125	16.29	23.13	0.787	0.838
		100x100x100	21.06	27.87	1.017	1.009
		75x75x75	21.16	28.35	1.022	1.027
M-2	M 25	150x150x150	27.43	32.74	1.0	1.0
		125x125x125	22.42	26.42	0.817	0.807
		100x100x100	28.02	32.90	1.021	1.005
		75x75x75	28.50	33.10	1.039	1.011
M-3	M 30	150x150x150	31.17	39.62	1.0	1.0
		125x125x125	25.55	34.67	0.819	0.875
		100x100x100	31.72	40.71	1.017	1.028
		75x75x75	32.49	41.28	1.042	1.042
M-4	M 35	150x150x150	32.85	44.02	1.0	1.0
		125x125x125	26.06	38.82	0.793	0.882
		100x100x100	33.04	44.50	1.006	1.020
		75x75x75	35.23	45.56	1.072	1.035

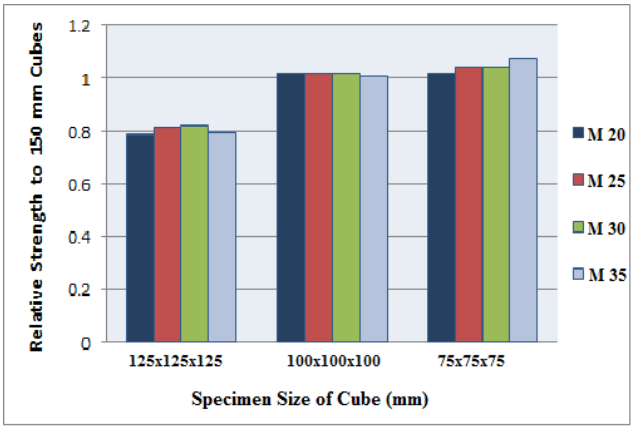

Fig.7: Effect of specimen size on Relative 7-days compressive strength of concrete

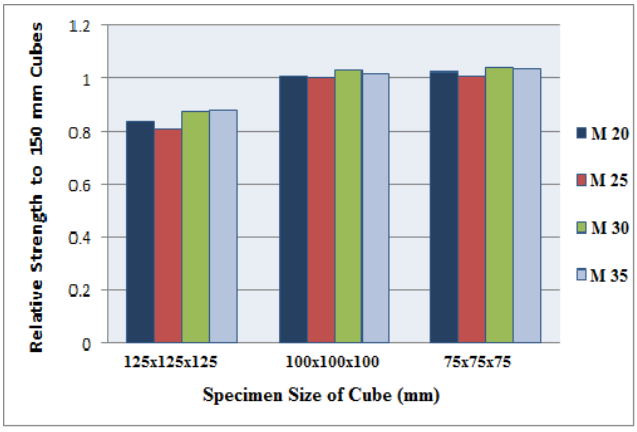

Fig.8: Effect of specimen size on Relative 28-days comp.str.conc.

IV. CONCLUSIONS

The following conclusions are drawn from the experimental investigations on size effects on cubes of different sizes:

1. There is a slight increase in the average compressive strength due to decrease in specimen size. The increase is more in 75 mm cubes as compared to other sizes of cubes.

2. However there is marginal decrease in compressive strength in case of 125 mm size cube. This may be due to the fact that the compressive strength increases up to certain limited decrease in size of specimen, beyond that the further decrease will contribute a slight increase in compressive strength.

3. Grade of concrete does not contribute much to the size effect. The variation in increase in compressive strength with decrease in specimen size was almost similar for all grade of concrete.

4. The average relative strength factor for 125 mm, 100mm & 75 mm size cube at the age of 7 days were obtained as 0.80, 1.015 & 1.044.

5. The average relative strength factor for 125 mm, 100mm & 75 mm size cube at the age of 7 days were obtained as 0.85, 1.016 & 1.030.

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